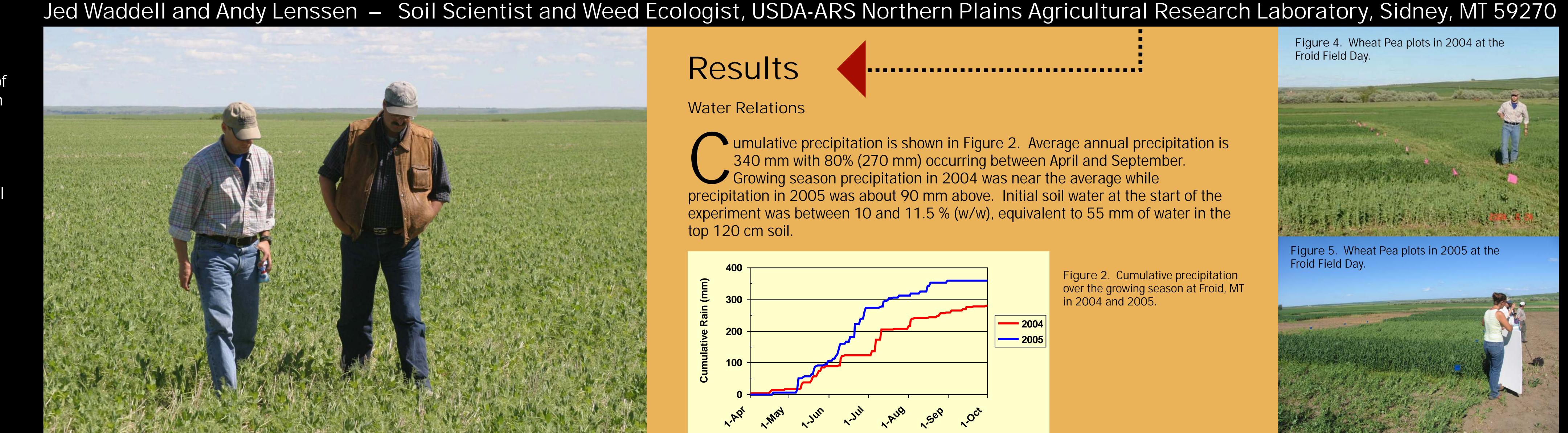
Effect of Phosphorus Fertilization Rates on Field Pea Nitrogen Production Agriculture Agriculture Research Service



Abstract

ield pea acreage in Montana has nearly quadrupled since 1997 because of its suitability to the climate and soils of the region and changes in the farm program. Usually in rotation with cereals, field pea provides a means to manufacture nitrogen from the atmosphere by nodulation with Rhizobium leguminosarum. This study attempts to determine whether P fertility has an impact on nitrogen production by the pea crop and the amount of N contributed to the following spring wheat crop. Treatments included two tillage systems, no-till and till, two crops (wheat and pea), and four P rates. Phosphorus as monoammonium phosphate was banded in no-till and broadcast in tilled plots at rates of 0, 20, 40, and 80 kg ha⁻¹ in both wheat and pea plots with urea to balance N. Wheat received additional N as urea to total 80 kg ha⁻¹. Initial soil P levels were 19 mg kg⁻¹. Pea yield ranged from 1.58 to 3.18 Mg ha⁻¹, linearly increasing with increased P rate. Total N uptake and biomass remaining on the field after harvest of field pea were not significantly different although N in harvested pea was different. Wheat yield did not respond to P fertility. Tillage led to increased wheat grain protein while the high P rates decreased wheat grain protein. First year results suggest that increased P fertility increases pea yield and protein but has a limited effect on N in residue.



he site was selected based on soil test values taken just north of the present study area

grown for hay. The hay-barley was fertilized with nitrogen but did not receive any P

The plots (3 × 9 m) were arranged as a split-plot with tillage as the whole plot and crop and P-

rate as the subplots. The crops were spring wheat and field pea with both components of the

mono-ammonium phosphate (11% N, and 52% P_2O_5) resulting in concomitant application of O_5

4, 8, and 16 kg N ha⁻¹. For pea plots, N as urea was added so the total N applied was 16 kg N

During the second year of the study, triple super phosphate (46% P₂O₅) was applied resulting in

Fertilizer was broadcast for tilled plots. Fertilizer was banded 5 cm below and 5 cm to the side

Soil samples were taken in spring and fall 2004 and 2005 for determination of water content,

nitrate, ammonia, and phosphate. Nitrate and ammonia will be analyzed by 5M KCl extraction

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rotation present each year. P-rates were 0, 20, 40, and 80 kg P₂O₅ ha⁻¹; P was applied as

ha⁻¹. For spring wheat plots, N as urea was added so the total N applied was 78 kg N ha⁻¹.

of the seed for no-tilled plots. Tillage was accomplished with a tool bar fitted with sweeps.

no N applied for field pea and similar rates as previous year for spring wheat.

and phosphate by 0.5M bicarbonate with pH adjusted to 8.5 (Olsen et al., 1954).

Statistical analyses were run with SAS using PROC MIXED.

averaging less than 10 mg P kg⁻¹ soil. Since that time, the field was cropped with barley

Methodology

Tillage was about 15 to 20 cm deep.

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Figure 1. Pea plots in 2004.

Introduction

nder the U.S. Farm Security and Rural Investment Act of 2002 (FSRIA), for the first time, pulses were included under the loan program. The loan rate provides a floor return because if the price is lower than the loan rate, the producer is eligible for a loan deficiency payment. As a result, pea (*Pisum sativum* L.) production in the northern Great Plains has exploded with 135,000 acres planted in 2005, an increase of 421 percent compared to 2002 (USDA, 2005). The typical cropping practice in the northern Great Plains is spring wheat (Triticum aestivum L.) followed by fallow. Producers are moving towards more intensive rotations, such as wheat field pea rotations, primarily based on economics.

Field pea is well suited to the northern Great Plains because it is a short, cool season legume with planting and harvest schedules different than wheat. This allows producers more time for field operations in wheat pea rotation. Water use of field pea is significantly less than that of wheat (Miller et al., 2003) making it an excellent rotational crop for water saving in semiarid regions. Pea requires no fertilizer nitrogen since it fixes its own from the atmosphere. Producers in the area rarely apply phosphorus and soil test P levels are generally low. This study was designed to determine the effects of various P fertilizer applications on yield and nitrogen production and carryover in wheat pea rotation.

> Much evidence suggests P fertilization increases yield. Will P fertilization enable field pea to produce more nitrogen for wheat in a wheat pea rotation?

Pea Response to Phosphorus Fertilizer

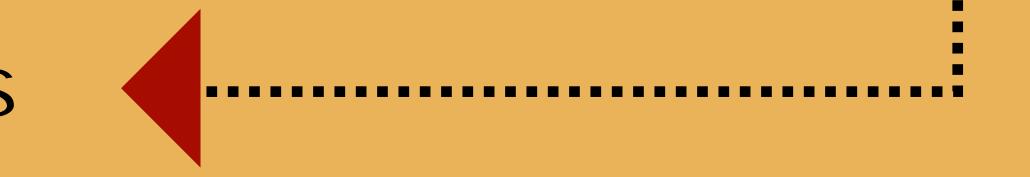
Karamanos et al. (2003) Increase yield with increased P fertilizer No increase in yield if soil >10 ppm P Max yield occurred at ~45 kg P₂O₅ ha⁻¹ Banded P application sometimes significant Fertilizer placed with seed reduced plant populations

Fertilizer Guidelines for Montana Crops – Maximum of 40 kg P₂O₅ ha⁻¹

Impact of Field Pea on Following Crop

Pulses will reduce fertilizer inputs and improve productivity (Campbell et al., 1990) Soon and Arshat (2004): 20 kg N hard credit to following crop Miller et al (2002):

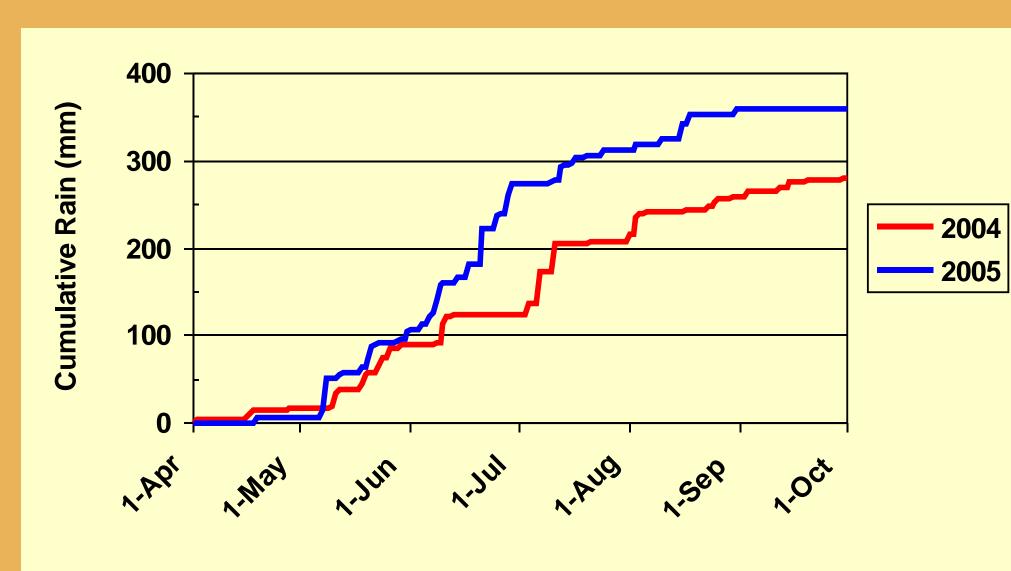
...a consistent N benefit provided by pulse crops to wheat ...rotational effects of pulse crops remain imprecise and inadequate.



Water Relations

umulative precipitation is shown in Figure 2. Average annual precipitation is 340 mm with 80% (270 mm) occurring between April and September.

Growing season precipitation in 2004 was near the average while precipitation in 2005 was about 90 mm above. Initial soil water at the start of the experiment was between 10 and 11.5 % (w/w), equivalent to 55 mm of water in the



over the growing season at Froid, MT in 2004 and 2005.

Water use was determined based on a mass balance approach (Water Use = Rain -Change in Storage). It was assumed that runoff and deep percolation were negligible; however, visual observations of site conditions indicated that runoff did occur during one event in 2005. Preplant and post-harvest soil water and water use is presented in Table 1. After the first season, there was more water after pea than wheat. Water use for field pea in 2004 was significantly less than wheat.

Winter and spring recharge of soil water was enough so that there were no differences in soil water during spring 2005 although field pea (after wheat) began with less soil water. Very dry conditions during the first month of the growing season caused poor establishment of pea and delayed emergence (Fig. 6). With above average rain in 2005, soil water actually increased for field pea over the growing season. Soil water was significantly less for spring wheat during the fall. Pea used significantly less water in than wheat.

Table 1. Spring and Fall Soil Water and Water Use for Pea and Wheat in 2004 and 2005

Date/Item	Field Pea	Spring Wheat	Significance
Spring 2004	86.3	89.5	ns
Fall 2004	69.9	60.7	P=0.0006
Water Use 2004	269	281	P<0.0001
Spring 2005	65.2	73.9	ns
Fall 2005	70.1	55.1	P<0.0001
Water Use 2005	353	377	P<0.0001

Yield and Quality

Pea Yield

Pea yields varied by year and phosphorus fertilization rate. 2004 had much greater yields (2.36 Mg ha⁻¹) than 2005 (1.08

Phosphorus fertilizer rates induced changes in yield (Figure 3). There was also a significant linear effect of yield.

It appears that the maximum yield of field pea occurred at around 40 kg P205 ha⁻¹.

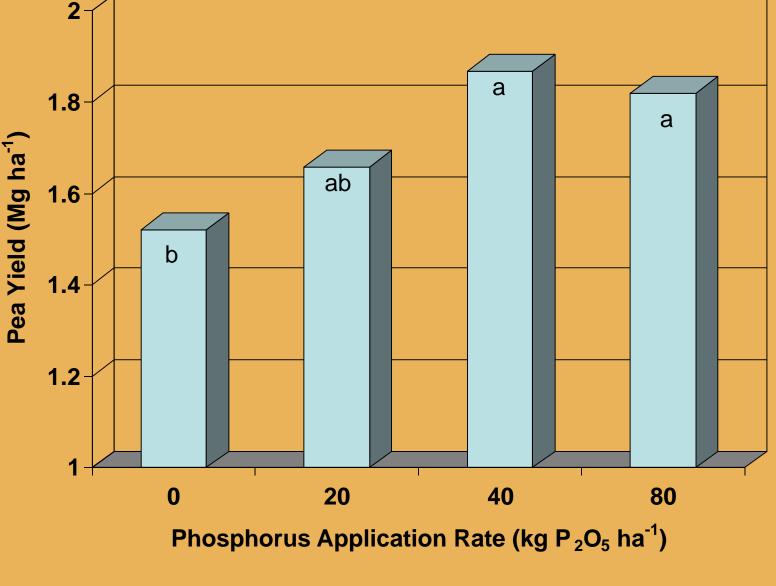


Figure 3. Pea yields over the various phosphorus application

Conclusions

oil P levels in the plots were higher than expected. At levels in the plots, State of Montana recommendations suggest no additional P application. However, we did observe a significant yield response to application of P.

- Pea uses 5 to 7 percent less water than wheat.
- Pea responded to phosphorus application even when soil P levels indicated P sufficiency.
- Wheat did not respond to P-application rates.
- Pea grain N uptake responded to increasing P-rates in 2004 (data not yet available for 2005).
- N in pea residue was not significantly different.

Total Pea Biomass

Figure 4. Wheat Pea plots in 2004 at the

igure 5. Wheat Pea plots in 2005 at the

Total pea biomass was significantly greater in 2004 than in 2005.

Figures 4 and 5 show obvious differences in plant growth in 2004 and 2005. Although the pictures were taken at different times of the growing season, it is

apparent the growth in 2005 was much less than 2004.

There were no differences in pea biomass yield over P or tillage treatments. As with total biomass, there were no significant differences in residue remaining in the field after harvest.

Field pea variety Majorette is a semi-leafless variety, thus little residue

Wheat Yield and Test Weight

Wheat grain yield did not differ among treatments or years.

Average wheat yield was 2.96 Mg ha⁻¹.

Test weight in 2005 (886 kg m⁻³) was less than in 2004 (938 kg m⁻³).

No tilled plots had significantly higher test weight (915 kg m⁻³) than conventionally tilled plots (908 kg m⁻³).

There was also a tillage x year interaction:

No difference between test weights in 2004 tillage treatments.

No-till had higher test weights than conventionally tilled treatments in 2005. Wheat stands were significantly greater in 2005 than in 2004, due to heavier seeding in 2005.

Nitrogen Dynamics (2004 Data Only)

Pea grain N content did not vary among treatments (Average, 3.76%). Spring wheat grain N content had significant tillage and P rate effects:

Higher grain N under conventional tillage.

Grain N decreased with increasing P additions.

Grain N uptake was significant in pea under various P rates (Fig. 6). Significant linear effect

Max grain N uptake between 50 and 60 kg P205 ha⁻¹.

No differences in grain N uptake in spring wheat.

Biomass and Residual N

No differences for Pea were observed in biomass N concentration, total N uptake, or residual N.

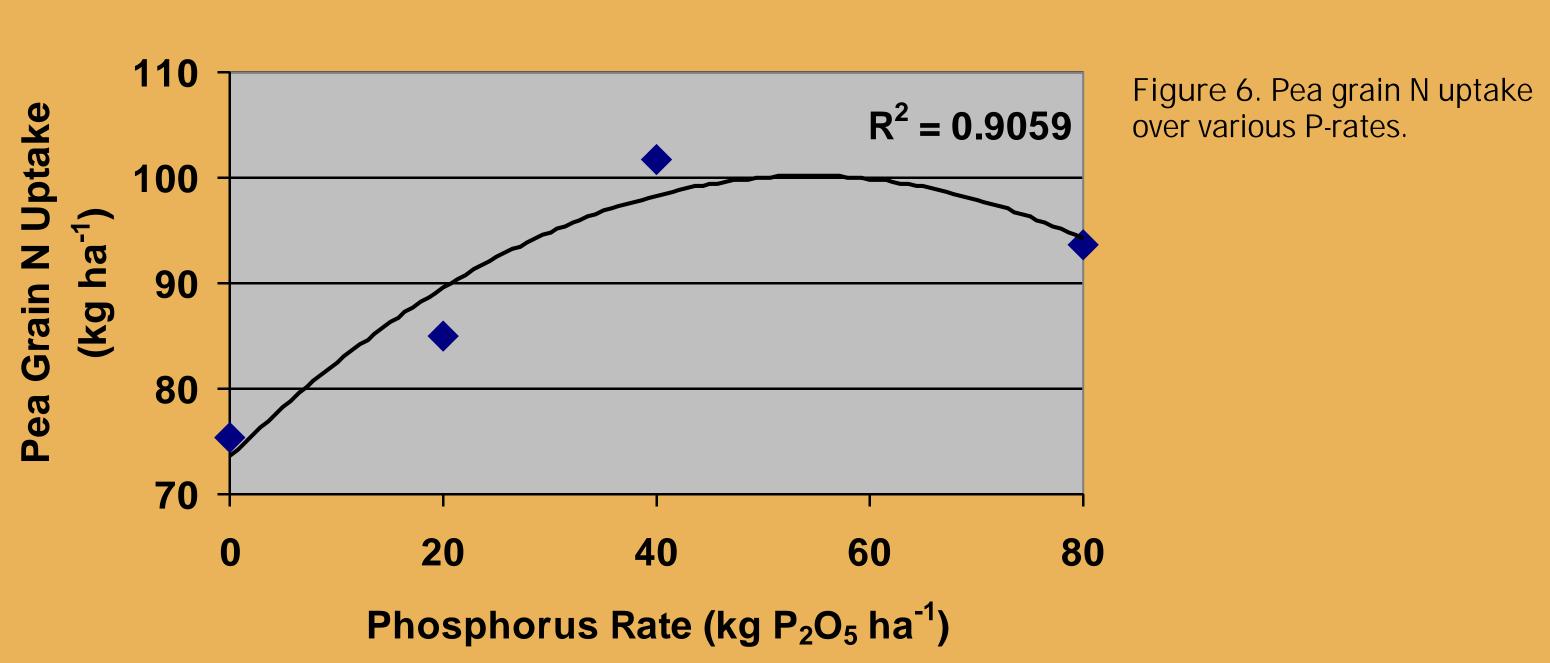
Tillage significantly increased biomass N concentration, total N uptake, and

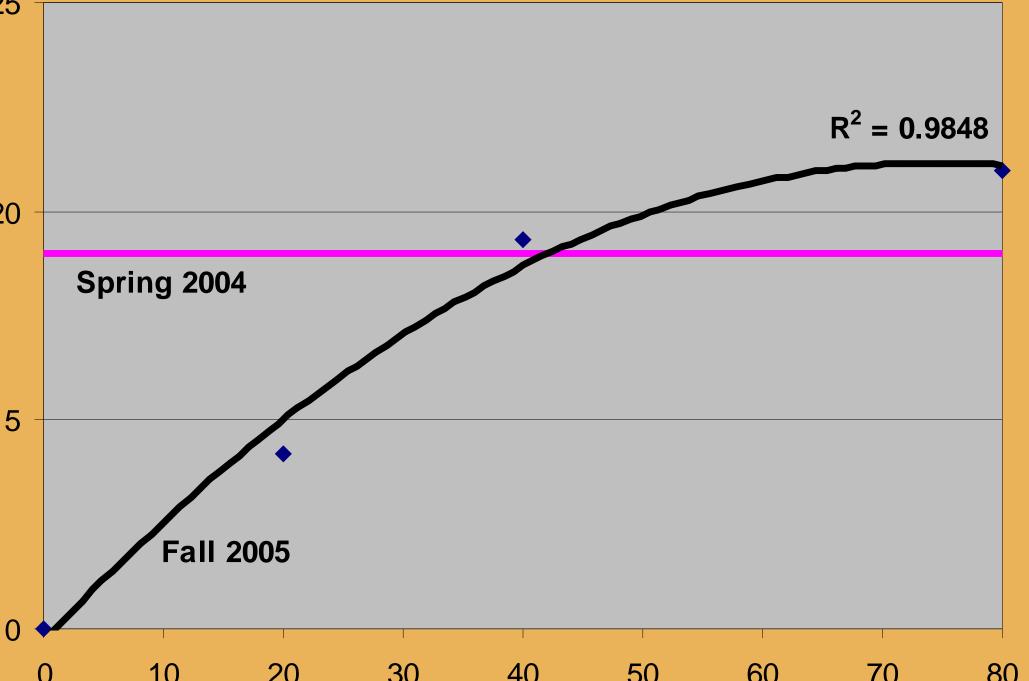
residual N in wheat.

P application rate was also significant for wheat biomass N concentration and total N uptake.

Initial Soil P was 19.0 mg P kg⁻¹ soil. Fall soil P in 2004 averaged 16.6 mg P kg⁻¹ soil.

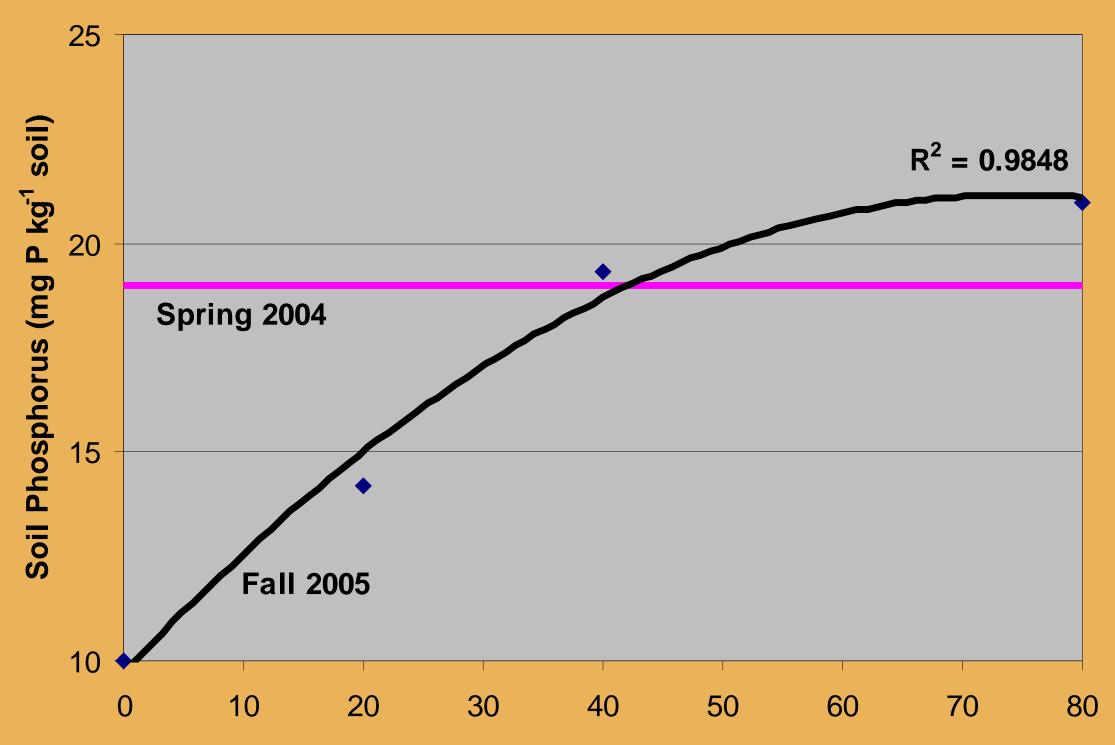
Spring soil P in 2005 averaged 16.7 mg P kg⁻¹ soil. Significant P rate response Fall 2005. (Fig. 7)





Phosphorus Rate (kg P₂O₅ ha⁻¹)

Figure 7. Soil Phosphorus changes after two growing



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